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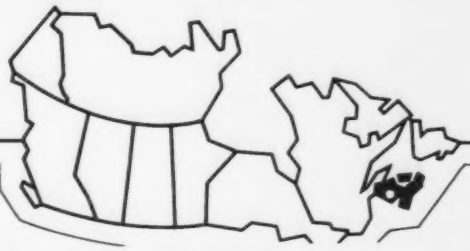

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A PRODUCTIVITY ORIENTED FOREST SITE CLASSIFICATION SYSTEM FOR NEW BRUNSWICK

by

H. van Groenewoud and A.A. Ruitenberg*

Maritimes Forest Research Centre

Fredericton, New Brunswick

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ABSTRACT

A modified forest site classification system for New Brunswick has been devised on the basis of climatic regions, geomorphologic districts, regolith systems, and site types. The system is based entirely on measured climatic, geological, mineralogical, and soil parameters, and was tested on 15 to 20-year-old black spruce (Picea mariana) plantations in northwestern New Brunswick. The height and volume growth of the plantations are significantly different among the various regolith systems but differ little within each system. Further applications and testing of the system to perfect it for intensive forest management are described.

RESUME

On a modifié la classification des stations forestières du Nouveau-Brunswick en se fondant sur les régions climatiques, les districts géomorphologiques, les systèmes régolithiques et les types de station. Ce système repose entièrement sur des paramètres climatiques, géologiques, minéralogiques et pédologiques mesurés et il a été mis à l'essai dans des plantations d'épinette noire (Picea mariana) de 15 à 20 ans du nord-ouest du Nouveau-Brunswick. La croissance en hauteur et en volume dans les plantations appartenant à divers systèmes de régolithes diffère beaucoup, mais elle varie peu à l'intérieur de chaque système. On décrit d'autres applications et essais visant à améliorer la classification en vue d'un aménagement forestier intensif.

DESCRIPTION OF SYSTEM

Several forest site classification systems, based on various combinations of parameters directly or indirectly related to climate, soils, drainage, and vegetation have been tried in New Brunswick over the past 30 years. The pros and cons, and causes for failure of these systems have been discussed by Page et al. (1979).[1]

The major reasons for the lack of use of these systems are the complexity of site conditions and forest history of the region, and, until now, the absence of an intensive forest management program. As a result of old logging practices, fires, and insect damage, natural forest communities are difficult to identify and growth estimates are difficult to obtain. Also some of the soil-geologic parameters that constitute important controls on forest growth are not clearly delineated in most systems.

In recent years, in response to an anticipated wood shortage, there has been a great increase in artificial reforestation of cut-over lands. The need for a practical site classification system has thus become very obvious.

To this end, we have devised and are proposing a forest site classification system somewhat similar to the biophysical or ecological land classification (Lacate 1969). The hierarchical levels are defined differently, however, and all are based on objectively determinable parameters (Table 1). This system has been developed as a major part of the Forest Site Classification Council of New Brunswick's effort to produce an efficient and generally acceptable site classification system for New Brunswick.

In ecological land classification, "ecoregions" are defined as having distinctive regional climates as expressed by vegetation (Lacate 1969). Our "climatic regions" are also defined as having distinctive regional climates, but they are established on the basis of the multivariate analysis of climatic data, only. An "ecodistrict" is defined as having a distinctive pattern of relief, geology, geomorphology and associated regional vegetation. Our "geomorphologic districts" are the surface expressions of major bedrock formations or groups, as modified by glacial and fluvial erosions.

We have deliberately avoided the use of vegetation as an internal part of the site classification system because of its much disturbed condition which can be misleading. To prevent confusion with earlier systems, we devised a descriptive terminology for the various levels of the new classification.

Climatic Regions

Van Groenewoud (1979)[2] compared maps of New Brunswick: a) Loucks ecoregions (1968), b) the provincial geology map (Potter et al. 1979), and c) the climatic regions of New Brunswick[3]. This comparison showed that the distribution of the major forest vegetation types (ecoregions) as recognized by Loucks (1968) did not reflect climatic differences as expressed by the climatic regions but conformed closer to the bedrock geology of New Brunswick. This is in conflict with the now generally accepted definition of an ecoregion (Lacate 1969), e.i., an area of land characterized by a distinctive regional climate as expressed by vegetation.

The climatic regions in the present study were delineated using three types of multivariate statistical analysis of meteorological data (van Groenewoud)[3]. The regions reflect a combination of latitude, gross scale physiographic features, marine influences, and storm tracks and are characterized by differences in temperature, rainfall, snowfall, number of degree days base 40°F (4.4°C), etc. These regions form the reference system for meso- and microclimatic descriptions at lower levels of the hierarchy, and constitute the first-order subdivisions of our proposed site classification system (Table 1). Examples of two contrasting climatic regions are the Fredericton and the Northern Uplands regions. The Fredericton region in June has 856.9 degree days and the Northern Uplands 590.8. The mean total rainfall in July is 83.9 mm in the Fredericton region, and 103.9 mm in the Northern Uplands regions.

Geomorphologic Districts

The surface expressions of major bedrock formations or groups (as delineated on bedrock geologic maps of the Province), modified by glacial and fluvial erosion, constitute the first-order control on the topography, and therefore on the drainage and mesoclimate in New Brunswick. In addition, it has been shown in regional geochemical studies in New Brunswick and elsewhere (following the method of Hawkes 1957), that oxygenated groundwater will remove mobile elements, including plant nutrients, directly from fractured bedrock. The geomorphologic district, the second-order subdivision in our proposed classification, therefore constitutes a broad characterization with respect to drainage, mesoclimate, and plant nutrient supply.

The following are examples of contrasting geomorphologic districts:

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[1]Page G., H. van Groenewoud, and J.C. Lees. 1979. Forest site evaluation in the Atlantic Region. Paper presented at the Can. Soil Sci. Soc. Meeting, Fredericton, N.B.

[2]Unpublished Report for the New Brunswick Forest Research Advisory Committee (1979).

[3]van Groenewoud H. The Climatic Regions of New Brunswick. A preliminary multivariate analysis of meteorological data. Manuscript in preparation, Maritime Forest Research Centre.

Table 1. Hierarchical levels of proposed forest site classification system

Unit	Description	Remarks
1. Climatic Region	A region having a distinctive climate delineated by multivariate statistical analysis of meteorological data.	These parameters constitute a broad control on forest growth and form the framework for meso- and microclimatic description.
2. Geomorphologic District	The surface expression of a major bedrock formation or group, modified by glaciation and fluvial erosion.	These parameters provide the first-order controls on drainage, topography, mesoclimate and nutrient supply.
3. Regolith System	a) Form and texture of landforms such as lodgement till, ablation till outwash, alluvial deposits etc. b) Lithologic-mineralogic composition (including percentage of material derived from different rock units and their secondary products) and structure (cleavage and fracturing) of the regolith material.	These parameters greatly affect drainage and limit nutrient availability within the regolith
4. Site Type	a) Soil profile characteristics b) Microdrainage c) Slope d) Position on slope e) Aspect f) Microclimate etc.	All of these parameters influence soil chemistry and/or soil physical properties and/or local climate, and hence influence forest growth at the individual tree and stand level.

a. The area southeast of the Loch Alva Fault, in the East Musquash Watershed is characterized by a gently rolling topography which resulted from relatively uniform glacial abrasion of the well-cleaved Precambrian basaltic volcanic rocks (Ruitenberg et al. 1975) (for terminology see glossary). Rowan (1973) noted that the soils here are richer in calcium and magnesium than those overlying the Devonian granitic rocks north of the fault. The higher calcium and magnesium contents of these soils can be attributed to the presence, in the regolith, of well-foliated mafic volcanic material that weathers quite rapidly.

b. The area northwest of the Loch Alva Fault, in the East Musquash Watershed is characterized by steep-sided ridges and valleys that resulted from glacial plucking of well-jointed Devonian granite (Ruitenberg et al. 1975). This ground is generally well drained, but the soils are poor. Coarse sand and gravel, derived from granite bedrock and overlying till, are characteristic. The low clay content in these soils reported by Rowan (1973) resulted from the removal of clay from the coarse sand and gravel by rapidly flowing surface water.

Regolith Systems

The third-order subdivision in our proposed classification is based upon the form and composition of the regolith that overlies the bedrock surface. In a general way, the effects of this parameter were described earlier in the Connecticut Valley (Lunt 1948) and northern Pennsylvania (Goodlett 1956).

The form, texture, and spatial distribution of residual materials, lodgement tills, ablation tills, eskers, kames, outwash, and alluvium are important features that must be carefully described. For example, the texture and compaction of the regolith (compare dense lodgement till with loose ablation till) determine its permeability (and therefore drainage), but also limit the surface area available for leaching in the Ae horizon.

In addition to form and texture, the regolith system is defined by its lithologic-mineralogic composition and structure (presence or absence

of cleavage and fractures in the rock fragments). These parameters determine the limits of plant nutrient production upon weathering. It is very important, wherever possible, to establish the percentages of the materials derived from different geologic formations. This is because recent information from this study and from other work indicates that in the Province the original depositional environments of various major rock units greatly affect their subsequent ability to release plant nutrients.

The following are some examples demonstrating this effect. In northwestern New Brunswick, very fertile soils are developed on well-drained tills that overlie the argillaceous and arenaceous limestones of the Ordovician-Silurian Matapedia Group (see study results). In contrast, soils notably poor for plant nutrient production have formed on equally well-drained till overlying the Lower Devonian micaceous siltstone and sandstone of the Temiscouata Formation.

In southern New Brunswick, excellent soils have developed on well-drained tills overlying bituminous shale, siltstone, and sandstone of the Upper Devonian-Lower Carboniferous Albert Formation. On the other hand, notably poor soils have formed on tills that are similarly well drained, but that overlie quartzose sandstone and quartz pebble conglomerate of the Pennsylvanian Boss Point Formation.

Forest Site Types

The forest site type, the final level in our proposed classification system, constitutes a subdivision of the regolith system upon which it has developed. Local criteria used to distinguish the forest site type include microdrainage, soil profile characteristics, slope, aspect, position on slope, microclimate, and stoniness. The first two of these parameters mainly control the variations in drainage and capacity to produce plant nutrients within a particular regolith system. Aspect or slope direction is an important microclimatic factor affecting the forest type. A well-known example of the effect of slope, aspect, and slope position is the occurrence of shade tolerant hardwoods such as beech and sugar maple on ridges and east-facing slopes.

METHODS

To provide an initial test of the validity of our proposed classification as a system for growth prediction purposes, we determined height growth curves and diameter growth in several black spruce (Picea mariana (Mill.) B.S.P.) plantations on comparable site types, within one climatic region, on several different geomorphologic districts and regolith systems (Fig. 1). The test area selected was on the Irving Woodlands Division holdings located at Veneer in northwest New Brunswick, where the bedrock is well mapped and where black spruce plantations of sufficient age for growth comparisons (15-20 years) are available.

All sites had been prepared for planting with a Letourneau crusher. The planting stock was 2-2 bare root black spruce. All plots were selected on site types that were comparable with respect to percent slope, aspect, position on slope, and drainage. However, they were situated on distinctly contrasting regolith systems.

Most older plantations are not fully stocked and are patchy. Random sampling would have included differences in tree growth due to differences in competition among the trees. Therefore, the sample plots were located only in fully-stocked parts of the plantations. To avoid edge effects, the plots were surrounded by at least one full row of trees.

In most heterogeneous systems such as forest stands or plantations, greater distances are associated with greater variability. If differences in growth between paired plots in close proximity are as great or greater than those between sets of paired plots at larger distances from one another, this can be accepted as an indication of homogeneity. This principle was used here to test the homogeneity, and hence usefulness, of each regolith system for forest productivity. Three sets of paired plots were established within each regolith system. Each plot contained about 36 trees. For each tree, all distances between the internodes, and the diameters midway between each pair of internodes were measured. The mean annual increments in height growth and the mean diameters between internodes were calculated for each plot, and growth curves were constructed. A total of 650 trees was thus measured and analyzed.

The above data were used to calculate mean total volume per tree, and to derive values for total volume per hectare and mean annual increment (MAI) per hectare for fully stocked plots. Because the measurements were made in even-aged and even-spaced plantations, it was decided to use the statistically more robust mean value of all trees on the plots instead of the mean of the values of a few of the largest trees, normally used to estimate site potential. Possible differences in growth due to small-scale habitat differences within a sample plot or genetic variation are thus diminished.

Soil pits were dug in each sample plot, soil profiles were described, and samples were taken for lithological-mineralogical examination and soil analysis (pH, cation exchange capacity, exchangeable Ca, Mg, K, available P, texture, and soil organic matter content). The soils were analyzed at the Soils and Tissue Analysis Laboratory of the Maritimes Forest Research Centre using the methods described by MacDonald (1977).

RESULTS

The sample plots are located in the Northern Uplands Climatic Region. Some of the climatic data characterizing this region are listed in Table 2; more complete information will be

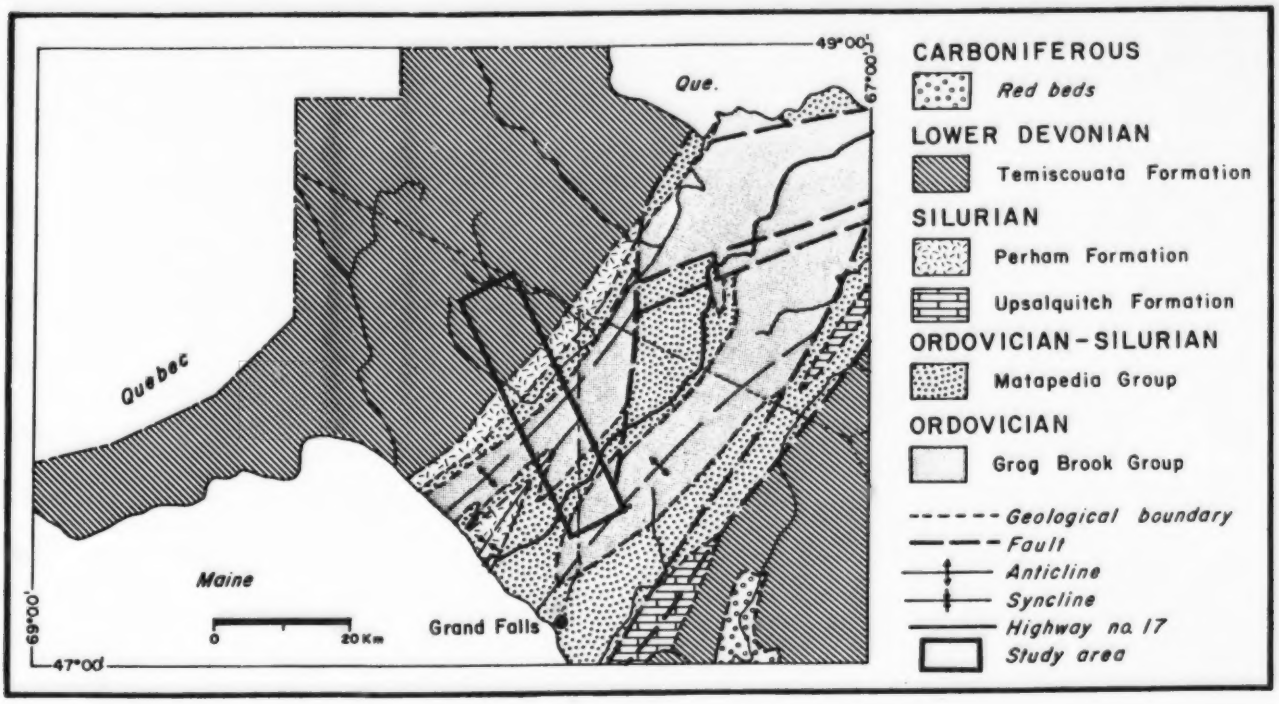

Fig. 1 Map showing geological formations and groups in northwestern New Brunswick (St. Peter 1978). Sampling area is indicated by rectangular block.

published shortly (van Groenewoud)[4].

Matapedia Sites

Geomorphologic District

The bedrock underlying this site is composed of interbedded, dense argillaceous limestone, soft shaley limestone, minor arenaceous limestone, calcareous shale and lithic limestone of the Ordovician and Lower Silurian Matapedia Group. These sediments were originally deposited by turbidity currents in a relatively deep bathyal or abyssal (see glossary) basin (St. Peter 1978). Relatively uniform glacial abrasion of the Matapedia bedrock surface resulted in the gently rolling topography that characterizes this area.

Regolith System

The regolith overlying the Matapedia bedrock surface is a basal till composed mainly of silty sand and clayey silt with varying amounts of rock fragments. The till thickness varies mostly from about 0.5 - 1 m, but it is locally thicker in the river valleys. In the southwestern part of the area, some thin patches of ablation till were mapped (C. Gauthier, pers. comm.)[5], but all sample sites were located on basal till.

Microscopic examination of sand-silt size material from the study area showed that it is composed of about 35% rock fragments comprising highly leached Matapedia lithologies, weathered Grog Brook argillite, rusty Temiscouata derived material, and minor green Perham slate, 55% siliceous and weathered feldspathic grains and 10% clay. The fine-grained siliceous and weathered feldspathic grains occur in varying proportions. The composition and texture of this fine-grained mixture resembles similar material in the till overlying the Temiscouata group and is, at least in part, derived from this unit. The Grog Brook group undoubtedly has contributed part of the siliceous and weathered feldspathic material, and some very small siliceous grains were observed also in leached Matapedia-derived fragments.

Sample Plot Site Description

The sample plots in the Matapedia regolith system are on level or slightly (less than 2°) sloping terrain (Table 3).

All sample plots were on well-drained sites, with a rooting depth varying from 30 to 35 cm. Stoniness in the C horizon varied from 30 to 70%.

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[4] van Groenewoud H. Summary of climatic data pertaining to the climatic regions of New Brunswick. Information Report in preparation, Marit. For. Res. Cent., Fredericton, N.B.

[5] Gauthier C. Navacel Enterprises Ltd., Suite 1208, 365 Bloor St. E., Toronto, Ontario.

Table 2. Monthly climatic data for the Northern Uplands Region

	Mean total rainfall (mm)	Mean total snowfall (cm)	Mean monthly temperature (°C)	Average growing degree days (base 40°F, 4.4°C)
January	6.4	64.0	-13.6	1.7
February	9.7	59.1	-12.7	2.2
March	14.2	54.3	- 6.3	17.3
April	39.3	28.2	3.7	93.4
May	78.0	3.0	8.0	348.6
June	97.4	0.1	14.0	590.9
July	103.9	0.0	16.8	698.2
August	102.0	0.0	15.4	668.4
September	93.3	0.0	10.5	432.0
October	83.9	6.1	4.7	205.1
November	48.8	36.1	- 2.2	51.1
December	23.4	66.1	-10.1	6.6

Table 3. Soil profile for Matapedia sample plots

Profile	Thickness (cm)	C/N ratio	pH	Color	Structure
L.F.H.	6-11	36	5.9,5.8,5.9		
Ae	2-7		4.1	Light grey	Weakly platy
B	20-32		5.6	Brown	Medium crumbly
C	Below 40		5.3	Brownish grey	Hard, with rock fragments

In the B horizons the exchange capacity ranged from 11 to 44 me % (me/100g) with a mean of 27.5 me %. The mean exchangeable Ca was 5.8 me % and exchangeable K was 0.06 me %. Available P varied around 53.6 ppm. In the entire profile, the sand fraction was about 50%, silt 40%, and clay 10%.

Grog Brook Sites

Geomorphologic District

The bedrock underlying these sites is composed of interbedded silty argillite, argillaceous sandstone, minor greywacke, conglomerate, argillaceous limestone, and arenaceous limestone of the Ordovician Grog Brook Group. The fine-grained rocks have a well-developed cleavage. The Grog Brook sediments show the characteristics of distal turbidite deposits that were deposited in a bathyal or abyssal marine environment (St. Peter 1978). Glacial abrasion of the Grog Brook surface resulted in a rolling topography. In general, relief in this area is somewhat steeper than in the area underlain by the Matapedia Group.

Regolith System

The regolith overlying the Grog Brook surface is a basal till that varies in thickness from about 0.3 to 1 m and is thicker in the valleys. The texture of the till varies but it consists mostly of silty sand and clayey silt and contains varying amounts of rock fragments.

Microscopic examination of the sand-silt size material showed that it is composed of about 28% rock fragments comprising dark-grey to rusty orange weathered Grog Brook argillite and smaller amounts of highly leached Matapedia lithologies, intensely weathered and rusty Temiscouata-derived material and minor green Perham slate, 63% siliceous and intensely weathered feldspathic grains, and 9% clay. The fine-grained siliceous and weathered feldspathic grains occur in varying proportions. The composition and texture of this fine-grained mixture resembles similar material in the till overlying the Temiscouata group and it is, at least in part, derived from this unit, but it undoubtedly also contains products resulting from weathering of local lithologies.

Sample Plot Site Type Description

The sample plots on the Grog Brook regolith system are on level terrain (Table 4). All sample plots were on well-drained sites, with a rooting depth varying from 35 to 46 cm. Stoniness in the C horizon varied from 30 to 70%.

In the B horizons the exchange capacity ranged from 9.9 to 18 me % with a mean of 11.5 me %. The mean exchangeable Ca was 0.3 me % and the exchangeable K 0.06 me %. Available P varied around 108 ppm. In the whole profile the sand fraction was about 55%, the silt fraction 35%, and the clay 10%.

Table 4. Soil profile for Grog Brook sample plots

Profile	Thickness (cm)	C/N ratio	pH	Color	Structure
L.F.H.	4-6	37.6	4.6,4.3,4.2		
Ae	4-7.5		4.4	Greyish white	Weakly platy
B	35-40		4.4	Greyish brown	Medium crumbly
C	Below 49			Brownish grey	Hard, with rock fragments

Temiscouata Sites

Geomorphologic District

The bedrock underlying these sample plots is composed of micaceous siltstone and slate with interbeds of arkose, greywacke and polymictic conglomerate of the lower Devonian Temiscouata Formation (St. Peter 1978). These sediments were originally deposited as a result of marine transgression and relatively rapid subsidence (Ruitenberg et al. 1977). The rocks generally have a well-developed cleavage. Glacial erosion of the intensely foliated Temiscouata bedrock surface resulted in a typical steeply rolling or hilly topography with deep incised river valleys.

Regolith System

The regolith overlying the Temiscouata bedrock is a basal till composed of quartz-rich sand, silt, clay, and numerous locally derived rock fragments. The till varies mostly in thickness from 0.3 to 1 m, but it is commonly thicker in the river valleys.

Microscopic examination of the sand-silt size material showed that it is composed of about 17% leached and oxidized, but still identifiable, locally derived rock fragments, 75% siliceous and intensely weathered feldspathic grains, 8% clay, and some fine micaceous material. In the fine-grained mixture of siliceous and weathered feldspathic grains, the former are most abundant, but the proportions differ between samples. The two components of this mixture, at least in part, have been derived from intense weathering of siltstone, which is the dominant lithology in the Temiscouata group. The coarser siliceous grains in the tills are derived from sandstone and conglomerate beds in the Temiscouata. The Temiscouata group occupies a large area in northwestern New Brunswick and has contributed material to all the tills in the study area.

Sample Plot Site Description

The sample plots on the Temiscouata regolith system are on slightly sloping (0.5°) terrain with a southerly and southwesterly exposure (Table 5).

All sample plots are on very well-drained sites with a rooting depth varying from 20-35 cm. There were large numbers of rock fragments in the C horizons.

In the B horizons the exchange capacity ranged from 13.5 to 28.6 me % with a mean of 22.5 me %. The exchangeable Ca ranged from 0.06 to 0.20 me % and the exchangeable K from 0.08 to 0.10 me %. Available P ranged from 6.3 to 28.0 ppm with a mean of 17.2 ppm. The texture of the soil was 68% sand, 24% silt, and 8% clay.

EVALUATION

Several of the differences in soil properties between groups of sample plots can be explained by the mineralogical-lithological composition of the three regolith systems, e.g., the higher pH of the various soil horizons on the Matapedia sites can be explained by the calcareous nature of these rocks. It is also reflected in the high exchangeable Ca. The high available P in the soils developed on the Grog Brook regolith is due to the abundance of argillaceous rock fragments derived from the Grog Brook Group. The soils developed upon the intensely leached, quartz-rich Temiscouata regolith have a notably low exchangeable Ca and available P. The slightly higher K in the Temiscouata soils is mainly due to relatively rapid weathering of feldspar and mica in these well-foliated rocks.

Mixing of Temiscouata-, Matapedia-, and Grog Brook-derived material, in the central and southern part of the study area, produced regoliths that are relatively well supplied with

Table 5. Soil profile for Temiscouata sample plots

Profile	Thickness (cm)	C/N ratio	pH	Color	Structure
L.F.H.	3-7	38.6	4.1,4.0,3.9		
Ae	3-16		3.9	Grey white	Medium platy
B_1	5-10		4.2	Dark brown	Medium granular
B_2	6-12		4.3	Lighter brown	Medium granular
C	Below 39 - 43		4.5	Grey brown	

potassium, calcium and phosphorus. Part of these nutrients are undoubtedly supplied by circulating groundwaters that leach mobile elements directly from fractured bedrock, but confirmation of this requires further investigation.

Height Growth

The height growth curves show distinct separation among the three regolith systems (Fig. 2). The Matapedia sites show the best growth, averaging 40 cm/yr (15.7 in/vr) between ages 6 and 10, and 48 cm/year (18.9 in/year) between ages 10 and 15 (Table 6). The mean height was 4.45 m (14.6 ft) at age 14. The tree heights at that age ranged from 4.05 m (13.3 ft) to 4.88 m (16 ft); a difference of 0.83 m (2.7 ft).

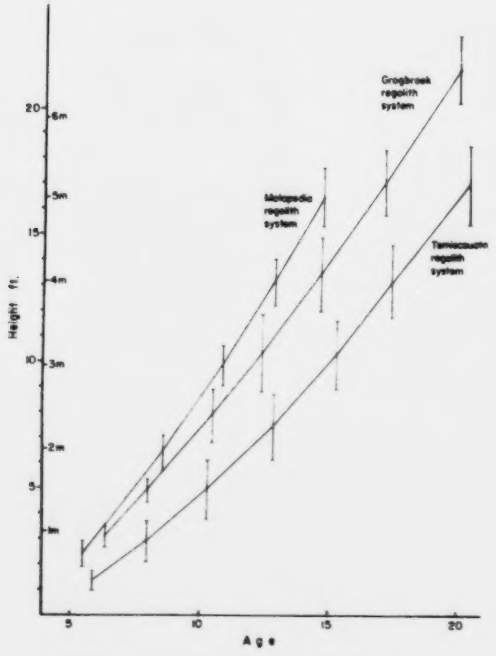

Fig. 2 Height growth curves of black spruce on well-drained level sites on three regolith systems, Matapedia, Grog Brook, and Temiscouata. Ranges are indicated by vertical lines.

The Grog Brook sites showed less height growth than the Matapedia sites. The mean growth rate between ages 6 and 10 was 36 cm/year (14.2 in/year), between ages 10 and 15, 41.2 cm/year (16.2 in/year) and between ages 15 and 20, 47 cm/year (18.5 in/year) (Table 6). The mean height was 3.92 m (12.5 ft) at age 14 and 6.45 m (21.5 ft) at age 20. The tree heights at age 14 ranged from 3.23 m (10.6 ft) to 4.18 m (13.7 ft); a difference of 0.95 m (3.1 ft). At age 20 the heights ranged from 6.04 m (19.8 ft) to 6.86 m (22.5 ft); a difference of 0.82 m (2.71 ft).

Height growth on the Temiscouata regolith system was considerably less than on either the Matapedia or the Grog Brook systems. The mean height growth between ages 6 and 10 was 26 cm/year (10.2 in/year), between ages 10 and 15, 32.3 cm/year (12.7 in/year), and between ages 15 and 20, 42.2 cm/year (16.6 in/year) (Table 6). The mean height at age 14 was 2.63 m (8.6 ft) and at age 20, 5.03 m (16.5 ft). The individual tree heights at age 14 ranged from 2.21 m (7.3 ft) to 3.05 m (10 ft); a difference of 0.84 m (2.8 ft). At age 20 the heights ranged from 4.54 m (14.9 ft) to 5.52 m (18.1 ft); a difference of 0.98 m (3.2 ft).

Table 6. Mean yearly height growth

Ages	Matapedia cm/year	Grog Brook cm/year	Temiscouata cm/year
6-10	40.0	36.0	26.0
10-15	48.0	41.2	32.3
15-20	no data	47.0	42.2

The differences in height growth between paired plots were as great or greater than between sets of paired plots, indicating the relative homogeneity for height growth of the regolith systems.

Volume Growth

For comparison, the present mean annual increment (MAI) in total stem volume was calculated for each fully-stocked sample plot. Plantation ages range from 15 to 20 years, and MAI values are therefore comparable in relative terms only[6]. Full stem analysis of representative sample trees will be necessary to permit more precise comparisons at a later date.

The MAI's of the fully stocked sample plots on the different regolith systems were: Matapedia (at 15 yr) 4.66 $\pm$ 0.60 m^3/ha; Grog Brook (at 20 yr) 5.58 $\pm$ 0.88 m^3/ha; and Temiscouata (at 20 yr) 2.88 $\pm$ 1.13 m^3/ha.

The volume growth on the Matapedia sites does not differ significantly from that on the Grog Brook sites, though it may do so by age 20. Both the Matapedia and the Grog Brook sites have significantly higher volume growth than the Temiscouata sites.

Not all plantations were fully stocked. In the vicinity of the (fully stocked) sample plots, the Matapedia plantations averaged 57% stocking, the Grog Brook plantations 69%, and the Temiscouata plantations 53%. Projected volume yields for fully-stocked plots would have to be scaled down by similar proportions to yield meaningful estimates of growth over larger areas.

[6]MAI values tend to increase with age during the earlier part of the rotation.

SUMMARY

Our results support the use of regolith systems as a basis for differentiation at the third level of the forest site classification.

The variability between paired plots was as great or greater than the variability between sets of paired plots. This indicates a certain homogeneity of forest productivity within each regolith system and sufficient differences between regolith systems to consider these systems recognizable units with respect to tree growth.

CONCLUSIONS AND RECOMMENDATIONS

1. The forest site classification system proposed in this report makes it possible to estimate forest growth for black spruce in the large area underlain by the Matapedia and Grog Brook Groups and the Temiscouata Formation of northern New Brunswick. It is recommended therefore that the proposed system be further tested as a guide for forest management throughout the Province.

2. The parameters in the proposed system can be determined objectively and define distinctive areas such as climatic regions, geomorphologic districts, regolith systems, and site types that can then be relatively rapidly mapped by field personnel trained in the method.

3. Some variables, especially at the first and second level, can be assessed directly from existing geologic and climatic maps. The determination of others, at the third and fourth level, will require additional field work, particularly in areas where no detailed surficial geological and soils information is available.

4. At the fourth level, we propose that special attention be paid to drainage, as it is an important limiting factor. We further propose that at this level empirical relationships be established between yield or height growth, or both, and those factors that operate mainly at this level: soil profile, slope, aspect, position on slope, etc. Success at this level will provide ultimate proof of the validity of the entire classification system.

5. In addition to growth related parameters, our proposed system also provides detailed information on terrain characteristics, which are important for site preparation before planting and for other management related activities.

6. Although the present testing of the system was carried out in plantations, it is recommended that the system should also be applied in areas where natural forest stands are intensively managed. This could provide valuable information for future reforestation and forest management programs.

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GLOSSARY

Ablation Till. Loosely consolidated rock debris, formerly contained by a glacier, that was deposited as the glacier melted. Some lodgement till reworked by meltwaters is usually included in units mapped as ablation till.

Abyssal. Pertaining to ocean environment at a depth of 500 fathoms or deeper.

Alluvium. A general geologic term for clay, silt, sand, and gravel deposited by running water during comparatively recent time.

Arenaceous. Pertaining to sediment or sedimentary rock consisting wholly or in part of sand-size fragments.

Argillite. A compact rock, derived either from mudstone (claystone or siltstone) or shale, that has undergone a higher degree of induration than mudstone or shale but is less clearly laminated and without distinct fissility.

Esker. A long, low, narrow, sinuous, steep sided ridge or mount composed of irregularly stratified sand and gravel that was deposited by a subglacial or englacial stream flowing between ice walls or in an ice tunnel of a continuously retreating glacier. It may be branching, is often discontinuous, and its course is usually at a high angle to the edge of the glacier. Eskers range in length from less than 1 km to more than 160 km and in height from 3 to 30 m.

Fluvual Deposit. A deposit produced by the action of a stream or river.

Geologic Environment. Formations composed of materials that were deposited or emplaced in many different ways. Clastic sediments such as gravel, sand, and mud deposited in river beds, lakes, deltas, continental shelves and slopes, and ocean deeps; other sediments such as limemuds deposited by chemical and biochemical precipitation in shallow marine seas in tropical climates; gypsum, anhydrite, salt, and potash deposited in restricted marine basins as a result of sea water evaporation in arid climates; volcanic flows and tuffs deposited on land, in shallow seas, and on the ocean floors; intrusive rocks such as gabbros and granites formed from molten magmas or melting rocks deep in the earth's crust. When rocks composed from materials of such a variety of origins are incorporated in a regolith, their plant nutrient content and resistance to weathering still greatly reflect their original depositional environment. This is why it is important to express the composition of the regolith in terms of percentages of their original materials.

Geomorphology. The science that treats the general configuration of the Earth's surface; specifically the classification, description, nature, origin, and development of present landforms and their relationships to underlying structures, and the history of geologic changes as recorded by these surface features. The term is especially applied to the genetic interpretation of landforms, but also to features produced by erosion or deposition.

Greywacke. A grey, greenish grey or black, very hard, tough and firmly undurated, coarse-grained sandstone consisting of poorly-sorted, angular to subangular grains of quartz, feldspar, and rock fragments in a clayey matrix.

Kame. A long, low, steep-sided hill, mound, knob, hummock, or short irregular ridge, composed chiefly of poorly sorted, stratified sand and gravel deposited by a subglacial stream as an alluvial fan or delta parallel to the melting edge of a glacier.

Lodgement Till. A basal till characterized by compact fissile structures and containing stones that were deposited by and underneath a glacier. Large stones are often oriented parallel to the direction of ice movement.

Outwash. Stratified sand and gravel washed out from a glacier by meltwater streams and deposited in front of the ice contact.

Regolith. A general term for the layer or mantle of fragmented loose, incoherent or unconsolidated rock material, of many origins (residual or transported) and of varied character, that forms the surface of the land and covers the more coherent bedrock. It includes all kinds of rock debris (weathered in place) volcanic ash, glacial drift, alluvium, loess and eolian deposits, vegetal accumulations and soils.

Rock Formation. The fundamental unit in the local classification and mapping of rocks (recognizable at a scale of 1:50,000) characterized by distinct kinds of rocks and physical features (such as color, mineralogical and chemical composition, structures, textures or gross aspects of fossils), and by a prevailing but not necessarily tabular shape, and a thickness ranging from a few metres to several thousand metres. The formation is used in mapping, describing or interpreting the geology of regions throughout the world. Every formation was originally deposited or emplaced in a distinct geologic environment.

Rock Group. A major unit next higher in rank than formation, consisting of two or more contiguous or associated formations having significant rock features in common.